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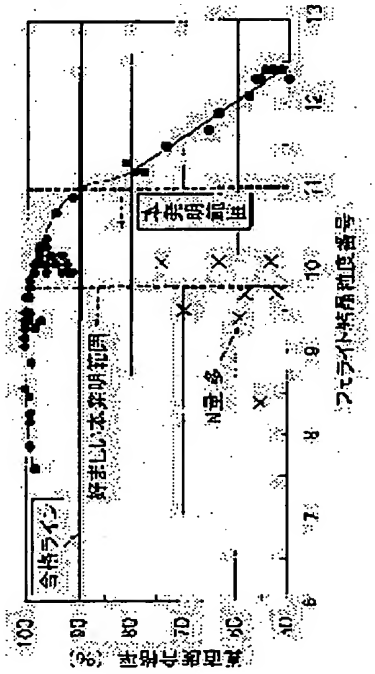
(54) STEEL PRODUCT EXCELLENT IN STRAIGHTNESS AFTER COLD DRAWING

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a steel product improved in the straightness (straightness after cold drawing) of a roller shaft necessary to attain high paper feeding accuracy which is the problem of a feeding/discharging roller, and a useful method for manufacturing such a steel product.
SOLUTION: The steel product has ferrite crystal grain size No. 11.0 or below by the grain size number by JIS G 0552, and the content of N is regulated to ≤0.1%. Such a steel product can be manufactured by finishing hot working at ≥800° C and carrying out cooling through the temperature region from 800 to 600° C at ≤ 3.0° C/s cooling rate.



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* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] A ferrite grain size is JIS. G Steel materials excellent in the Masanao nature after cold drawing processing characterized by being less than No. 11.0 by the grain-size number by 0552, and the content of N being below 0.01% (it being the same the semantics of mass %, and the following).
[Claim 2] The steel materials according to claim 1 which less than [aluminum:0.05%] (0% is included) is contained [steel materials] C:0.15% or less (0% is not included), respectively less than [Si:0.05%] (0% is included), Mn:0.3-2%, P:0.2% or less (0% is included), and S:0.08 to 0.5%, and make machinability provide.
[Claim 3] Furthermore, less than [Pb:0.4%] (0% is not included), less than [Bi:0.4%] (0% is not included), Te: The steel materials according to claim 2 which are the things containing one or more sorts chosen from the group which consists of less than [0.2%] (0% is not included), less than [Se:0.3%] (0% is not included), less than [Sn:0.4%] (0% is not included), and In:0.4% (0% is not included).
[Claim 4] The manufacture approach of steel materials excellent in the Masanao nature after cold drawing processing characterized by cooling a 800-600-degree C temperature requirement with the cooling rate of 3.0 degrees C/second or less after ending hot working at the temperature of 800 degrees C or more in manufacturing steel materials according to claim 1 to 3.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the useful approach for manufacturing the steel materials which were especially excellent in the Masanao nature after cold drawing processing, and such steel materials about steel materials, such as a wire rod used for feeding of the various paper feed rollers used with a printing machine or a copying machine among the high degree of accuracy and the rollers for high-speed conveyance which are used by an industrial machine etc., a bill delivery roller, etc., and a delivery roller shaft, and a steel bar, and the manufacture approach of those.

[0002]

[Description of the Prior Art] In recent years, improvement in the speed and multicolored-printing-izing (colorization) of a copying machine or a printing machine follow on being advanced, and feeding and the delivery roller which importance is attached to a high paper feed precision, and are used by the above-mentioned industrial machine from such a thing are also expected a high precision.

[0003] if in charge of manufacturing the above feeding and a delivery roller — first — a line — although the steel bar which corrected [which corrected right and cold-drawing-processed it] the rolled steel is cut to die length predetermined and the round bar which is a roller shank is produced, in order to raise the paper feed precision of a roller shank in such a manufacture approach, techniques various until now are proposed.

[0004] As one of such the techniques, raising grip nature with paper and raising paper feed precision to a metal round bar periphery side by forming two or more letter projections of a spike, by plastic working, is indicated by JP,11-20962,A. Moreover,

the technique which raises grip nature with paper and raises paper feed precision is proposed by JP,10-329971,A by fixing abrasive grains, such as an alumina and silicon carbide, on a metal round bar front face. Furthermore, it is shown to JP,8-301496,A by by covering a metal round bar front face with rubber that make grip nature with paper increase and the high feeding nature of precision is attained.

[0005] However, each above-mentioned technique proposed until now is not what examined the property of the round bar that all are made from a viewpoint of adjusting the shape of the front planarity, and serve as the material. That is, although it will become an important property fundamentally that the round bar primarily used for a roller shank is ****** and that the Masanao nature after cold drawing processing is high if it puts in another way in order to raise paper feed precision, the actual condition is that the technique examined from such a viewpoint is hardly proposed until now. It is [that the technique of raising the Masanao nature slightly as such a technique by fixing the nitrogen in steel for machine structural use to JP,4-168244,A as AlN by aluminum, and reducing dissolution nitrogen is only proposed, and].

[0006]

[Problem(s) to be Solved by the Invention] This invention is made under such a situation and the purpose is in offering the useful approach for manufacturing the steel materials which have improved the Masanao nature (Masanao nature after cold drawing processing) of a roller shank required in order to attain a high paper feed precision which poses a problem with feeding and a delivery roller, and such steel materials.

[0007]

[Means for Solving the Problem] For the steel materials of this invention which could attain the above-mentioned purpose, a ferrite grain size is JIS. It has a summary at the point that it is less than No. 11.0 by the grain-size number by G0552, and the content of N is 0.01% or less.

[0008] Although various free cutting steels are mainly targetted for the steel materials of this invention As the fundamental chemical entity presentation, C:0.15% or less (0% is not included), Si: Less than [0.05%] (0% is included), Mn:0.3-2%, P:0.2% or less (0% is included), and S:0.08 to 0.5%, what contains less than [aluminum:0.05%] (0% is included), respectively is mentioned, and machinability can be provided in steel materials by this.

[0009] In the steel materials of this invention, as occasion demands Moreover, less than [Pb:0.4%] (0% is not included), Bi: Less than [0.4%] (0% is not included), less than [Te:0.2%] (0% is not included), Se: It is also effective to contain one or more

sorts chosen from the group which consists of less than [0.3%] (0% is not included), less than [Sn:0.4%] (0% is not included), and less than [In:0.4%] (0% is not included).

[0010] What is necessary is just to make it cool a 800-600-degree C temperature requirement with the cooling rate of 3.0 degrees C/second or less, after ending hot working at the temperature of 800 degrees C or more on the other hand in manufacturing the steel materials of this invention.

[0011]

[Embodiment of the Invention] It was thought that the main causes which deflection produces in the cold finished steel bar which was able to cold-drawing-process it, and set right, and was able to obtain the rolled steel originated in the residual stress which remains in the cold-finished-steel-bar surface section after cold working. Then, this invention persons inquired from a viewpoint of reducing the above residual stress. Consequently, in order to reduce residual stress, while it is effective to make small the rate of work hardening of steel materials and it made the diameter of ferrite crystal grain the proper value for that purpose, a header and this invention were completed for what is necessary being just to reduce a nitrogen content.

[0012] Since the wire rod wound around the coiled form is used for the rolled steel used for feeding and delivery roller shafts, the rolled-steel inside surface section which was round to the coiled form has shrunken compared with the rolled-steel wood core (axial center section). For example, as shown in drawing 1 , when die length which has shrunken center line die length is set to epsilon (namely, the die length of the inside surface section S-epsilon), as for the outside surface section, only die-length epsilon will be extended (namely, the die length of the outside surface section S+epsilon). And even if the steel bar with which the rolled steel of such a condition was extended, cold drawing processing was carried out, it deformed plastically and only L was extended is obtained, the difference (2epsilon) of the elongation of the amount shown by following the (1) formula will exist in the inside surface section and the outside surface section from the first (drawing 2).

(S+epsilon+L) - (S-epsilon+L)=2epsilon .... (1)

[0013] Therefore, since the residual stress resulting from the difference (2epsilon) of the elongation which was carried out plastic deformation -> elastic recovery by cold drawing processing and which was drawn out and described above in the surface section of a steel bar arises, deflection occurs in a drawing steel bar. And even if it covers such a drawing steel bar over a straightening machine, and makes it a cold finished steel bar, it bends and it reduces an amount, it cannot become a fundamental solution means for improving the Masanao nature of steel materials.

[0014] It is important to stop as low as possible the stress which makes small inclination d epsilon/d sigma of the plastic deformation field of a stress-strain curve, and originates in 2epsilon as above-mentioned The means for solving a technical problem from such a thing. In other words, it is required to make the rate of work hardening as small as possible. And it found out that it was important to enlarge the diameter of ferrite crystal grain first (to make a ferritic grain size number small), and it was important to control the nitrogen which is the component which causes the rate increase of work hardening as the 2nd means as much as possible out of steel materials for that purpose.

[0015] The steel materials of this invention are JIS about the viewpoint mentioned above to a ferrite grain size. G Although the grain-size number by 0552 prescribes the content of less than No. 11.0 and N to 0.01% or less, these reasons for range limitation are as follows.

[0016] Ferrite grain size: JIS G By the grain-size number by 0552, a No. [less than] 11.0 ferrite grain size (ferrite particle size) is a parameter effective in reducing the rate of work hardening, if a ferritic grain size number exceeds No. 11.0, the rate of work hardening will become high too much, and the amount of deflection of the cold finished steel bar after correction will become large at a cold drawing processing list. In addition, the upper limit with a desirable ferritic grain size number is No. 9.8.

[0017] Drawing 3 is the graph which showed the relation between a ferritic grain size number and the rate of the Masanao nature success. It expresses with percent the rate of the Masanao nature success here by considering the rate of steel materials with an amount [of deflection] of 50 micrometers or less as success. It turns out that the ferritic grain size number has attained 90% of rates of success or less by 11.0, and about 100% of rate of success is obtained less than by No. 9.8 so that clearly from this drawing 3 .

[0018] When N:0.01% or less this invention persons investigated about the relation between the amount of deflection of the cold finished steel bar which set right in the cold-working list, and the amount of dissolution N in steel [N], it became clear that the amount of deflection of a cold finished steel bar became large, so that there was much dissolution in steel [N]. It is thought that it will become the factor in which deflection remains mostly even if residual stress which is greatly different at least in each part of a steel surface section circumferencial direction arises and it performs straightening after cold drawing processing by surface treatment if cold drawing processing of the steel materials wound around the coiled form is carried out, since a lot of existence of the dissolution in steel [N] increases work hardening of steel materials. In order not to

make the deflection of such a cold finished steel bar remain, it is necessary to reduce the dissolution [N] included in steel as much as possible. By this invention, N content in steel was specified as 0.01% or less from such a viewpoint. In addition, N content is good to consider as 0.008% or less preferably, and the effectiveness of this invention is attained by considering as this range to the maximum extent.

[0019] Drawing 4 is the graph which showed N content in steel, and the relation of the rate of straightness success (passage of the above [evaluation of the rate of success]). It turns out that N content has attained 90% of rates of success at 0.01% or less, and about 100% of rate of success is obtained at 0.008% or less so that clearly from this drawing 4 .

[0020] Although various free cutting steels are mainly targetted for the steel materials of this invention, the desirable range of C, Si, Mn, P, S, and aluminum which are the fundamental component, and its reason are as follows.

[0021] C:0.15%or less (0% is not included) C — predetermined reinforcement — giving — the front face after cutting — it is an element effective in making description (machined surface granularity) good. However, since it will become hard too much and a tool life will worsen if it is made to contain superfluously, it is good to make it to 0.15% or less. In addition, the more desirable minimum of C content is 0.05%, and a more desirable upper limit is 0.10%.

[0022] Si: 0.05%or less (0% is included) Si will be work hardened in order to carry out solid solution strengthening of the ferrite, if the fewer possible one is desirable and the content becomes superfluous, and it will have a bad influence on the Masanao nature. Moreover, the oxygen density in steel at the time of the dissolution falls that Si content is superfluous, the oxygen density in MnS falls, the gestalt of MnS becomes a disadvantageous thing for machinability, and machined surface granularity becomes coarse. As for such a viewpoint to Si content, controlling to 0.05% or less is desirable. In addition, the more desirable upper limit of Si content is 0.03%, and is good to consider as 0.01% or less still more preferably.

[0023] Mn: Although it is an element effective in Mn giving predetermined reinforcement 0.3 to 2%, since FeS generates that it is less than 0.3% and the liquid phase arises during rolling, it becomes easy to produce a crack. Although it is desirable to make Mn content into 0.3% or more from such a viewpoint, if Mn is added more than it forms MnS which contributes to scraps fragmentation nature, in order to cause work hardening and to have a bad influence on the Masanao nature by ferrite dissolution, it is good for the amount of S to make it to 2% or less in all. In addition, the more desirable minimum of Mn content is 0.5%, and a more desirable upper limit is 1.5%.

[0024] If P is made to contain, residual stress will become easy to produce P:0.2%or less (for 0% to be included) P on the cold-finished-steel-bar front face corrected in the cold drawing processing list, in order to gather the rate of work hardening. Moreover, the fewer possible one is desirable from raising the hardness of steel materials and shortening a tool life. Since a substantial bad influence [as opposed to the Masanao nature in P content] does not appear at 0.2% or less, P content is good to make it to at least 0.2% or less. In addition, the more desirable upper limit of P content is 0.1%, and the bad influence to the tool life by P hardly appears in this range.

[0025] Although S:0.008 - 0.5%S is added for a machinability improvement, at less than 0.008%, machined surface granularity becomes coarse. Although it is more desirable that it is 0.15% or more as for S content, if S content becomes superfluous and exceeds 0.5%, a surface crack will increase. In addition, the more desirable upper limit of S content is 0.4%.

[0026] aluminum: Since aluminum fixes N as AlN 0.05% or less (0% is included), you may add, but since this AlN bars migration of a rearrangement as the pinch effect, although it is smaller than the above-mentioned dissolution [N], it may bend, even if it performs cold drawing processing and straightening, and an amount may be affected. Such a viewpoint to the content is good to consider as 0.05% or less. Moreover, if the content of aluminum becomes superfluous exceeding 0.05%, since the oxygen density in steel at the time of about [causing the increment in work hardening by a lot of AlN(s) depositing] and the dissolution will fall and the oxygen density in MnS will fall, the gestalt of MnS becomes a disadvantageous thing for machinability, and machined surface granularity becomes coarse. In addition, the more desirable upper limit of aluminum content is 0.01%, and is good to consider as 0.005% or less still more preferably.

[0027] Although the fundamental chemical entity presentation at the time of applying a free cutting steel as steel materials of this invention is as above-mentioned and the remainder consists of Fe substantially, as occasion demands, it is also effective to add one or more sorts chosen from the group which consists of Pb, Bi, Te, Se, Sn, and In, and each of these contributes to machinability improvement. The reason for range limitation of each component when adding these is as follows.

[0028] Pb: Although less than [0.4%] (0% is not included) Pb is added for a machinability improvement, if Pb content becomes superfluous and exceeds 0.4%, hot-working nature will worsen, and the surface crack of rolled stock will increase. In addition, the upper limit with desirable Pb content is 0.3%.

[0029] Bi: Although it is an element effective in less than [0.4%] (0% not being

included) Bi raising the machinability of steel, if Bi is made to contain superfluously and it exceeds 0.4%, hot-working nature will worsen, and the surface crack of rolled stock will increase. In addition, the desirable upper limit of Bi is 0.3%.

[0030] Te: Although it is the element which Te forms the compound Mn with Mn (Te, S) with S 0.2% or less (0% is not included), and raises machinability, if the content of Te exceeds 0.2%, hot-working nature will fall, and the surface crack of rolled stock will arise. In addition, the desirable upper limit of Te is 0.15%.

[0031] Se: Although it is the element which Se forms the compound Mn with Mn (Se, S) with S 0.3% or less (0% is not included), and raises machinability, if the content of Se exceeds 0.3%, hot hardness will become high and machinability will fall on the contrary. In addition, the desirable upper limit of Se is 0.2%.

[0032] Sn: Although 0.4%or less (0% is not included) Sn is also an effective element for a machinability improvement, if the content of Sn becomes superfluous and exceeds 0.4%, hot-working nature will get worse, and the surface crack of rolled stock will increase. In addition, the desirable upper limit of Sn is 0.3%.

[0033] In: Although less than [0.4%] (0% is not included) In is also an effective element for a machinability improvement, if the content of In becomes superfluous and exceeds 0.4%, hot-working nature will get worse, and the surface crack of rolled stock will increase. In addition, the desirable upper limit of In is 0.3%.

[0034] It is effective in the steel materials of this invention besides the above-mentioned component to also make Cr, nickel, V, Ti, Nb, etc. contain, and although these contribute to high intensity-ization, when making these elements contain, it is desirable to consider as 1% or less respectively from a viewpoint of the Masanao nature and a tool life.

[0035] In addition, the minor constituent of extent which does not check the property besides the various above-mentioned components may be included in the steel materials of this invention, and such a free cutting steel is also contained in the technical range of this invention. As such a minor constituent, permission components, such as B and O, impurities, such as Cu, calcium, Mg, As, and rare earth elements, especially an unescapable impurity are mentioned.

[0036] Although what is necessary is just to make it, cool a 800-600-degree C temperature requirement with the cooling rate of 3.0 degrees C/second or less on the other hand in manufacturing the steel materials of this invention after ending hot working at the temperature of 800 degrees C or more, the reason for a convention of each requirement in this manufacture approach is as follows.

[0037] First, at less than 800 degrees C, even if hot-working termination temperature

(hot rolling finishing termination temperature) cools, it cannot obtain desired ferrite crystal grain. It is necessary to adjust but so that it may become 800 degrees C or more from such a thing about hot-working termination temperature at least by this invention approach, and in order to make a ferritic grain size number less than into No. 9.8, it is good to make hot-working termination temperature into 850 degrees C or more preferably.

[0038] Moreover, by this invention, in order to enlarge ferrite crystal grain, it is necessary to cool a 800-600-degree C temperature requirement with the cooling rate of 3.0 degrees C/second or less after hot working. When the cooling rate at this time exceeds a second in 3.0 degrees C /, ferrite crystal grain does not become large but the amount of deflection of the cold finished steel bar after cold drawing processing and correction is still large. From such a viewpoint, it is necessary to adjust the above-mentioned cooling rate but so that a second may come in 3.0 degrees C /or less, and in order to make a ferritic grain size number less than into No. 9.8, the above-mentioned cooling rate is good to make it desirable in 1.9 degrees C/second or less. In addition, the temperature requirement cooled with the cooling rate of 3.0 degrees C/second or less was made into 800-600 degrees C because the cooling rate near [which exists in this temperature region] the gamma/alpha transformation point had big effect on ferrite grain big and rough-ization.

[0039] Although an example explains this invention to a detail further below, the following example is not the thing of the property which limits this invention, and each thing marked and done to before and the after-mentioned meaning for a design change is included in the technical range of this invention.

[0040]

[Example] The various free cutting steels of the chemical entity presentation shown in the following tables 1 and 2 were prepared, and while ending rolling by the hot rolling finishing temperature which shows these in the following tables 3 and 4, respectively, the 800-600-degree C temperature requirement was cooled with various cooling rates, and it considered as the test specimen of 9.5mmphi.

[0041]

[Table 1]

略号	化学成分組成(質量%)							
	C	Si	Mn	P	S	Al	N	その他
A1	0.07	0.001	1.15	0.08	0.30	0.001	0.0028	-
A2	0.07	0.001	1.23	0.08	0.29	0.001	0.0057	-
A3	0.08	0.001	1.18	0.08	0.30	0.001	0.0075	-
A4	0.08	0.001	1.17	0.08	0.31	0.001	0.0098	-
A5	0.07	0.001	1.17	0.08	0.30	0.001	0.0125	-
A6	0.08	0.001	1.22	0.08	0.30	0.001	0.0151	-
A7	0.07	0.001	1.24	0.07	0.33	0.001	0.0211	-
B1	0.09	0.001	1.19	0.08	0.29	0.001	0.0049	-
B2	0.07	0.001	1.16	0.08	0.31	0.001	0.0053	-
B3	0.08	0.001	1.23	0.08	0.31	0.001	0.0051	-
B4	0.07	0.001	1.20	0.08	0.29	0.001	0.0055	-
B5	0.07	0.001	1.22	0.08	0.30	0.001	0.0057	-
B6	0.07	0.001	1.20	0.08	0.30	0.001	0.0052	-
B7	0.07	0.001	1.22	0.08	0.31	0.001	0.0051	-
B8	0.07	0.001	1.21	0.08	0.31	0.001	0.0049	-
B9	0.07	0.001	1.23	0.08	0.32	0.001	0.0053	-
B10	0.08	0.001	1.19	0.08	0.30	0.001	0.0055	-
B11	0.07	0.001	1.20	0.08	0.33	0.001	0.0054	-
B12	0.07	0.001	1.21	0.08	0.32	0.001	0.0048	-
B13	0.07	0.001	1.21	0.08	0.31	0.001	0.0050	-
B14	0.07	0.001	1.22	0.08	0.31	0.001	0.0052	-
B15	0.07	0.001	1.23	0.08	0.32	0.001	0.0053	-
B16	0.08	0.001	1.19	0.08	0.31	0.001	0.0054	-
B17	0.07	0.001	1.21	0.08	0.32	0.001	0.0052	-
B18	0.08	0.001	1.21	0.08	0.32	0.001	0.0052	-
B19	0.08	0.001	1.20	0.08	0.29	0.001	0.0048	-
B20	0.07	0.001	1.19	0.08	0.30	0.001	0.0049	-
B21	0.07	0.001	1.19	0.08	0.29	0.001	0.0053	-
C1	0.07	0.012	1.22	0.08	0.31	0.001	0.0052	-
C2	0.07	0.031	1.19	0.08	0.29	0.001	0.0049	-
C3	0.08	0.059	1.19	0.08	0.33	0.001	0.0050	-
C4	0.07	0.070	1.18	0.08	0.32	0.001	0.0048	-
D1	0.07	0.001	0.18	0.08	0.08	0.001	0.0051	-
D2	0.07	0.001	0.33	0.08	0.08	0.001	0.0053	-
D3	0.08	0.001	1.18	0.08	0.28	0.001	0.0045	-
D4	0.07	0.001	1.97	0.08	0.47	0.001	0.0052	-
D5	0.07	0.001	2.33	0.08	0.56	0.001	0.0050	-

[0042]

[Table 2]

略号	化学成分組成(質量%)							
	C	Si	Mn	P	S	Al	N	その他
E1	0.08	0.001	1.16	0.01	0.30	0.001	0.0049	-
E2	0.08	0.001	1.18	0.13	0.31	0.001	0.0048	-
E3	0.07	0.001	1.22	0.25	0.31	0.001	0.0052	-
F1	0.07	0.001	1.23	0.08	0.33	0.032	0.0052	-
F2	0.07	0.001	1.22	0.08	0.33	0.049	0.0051	-
F3	0.07	0.001	1.23	0.08	0.31	0.072	0.0054	-
G1	0.07	0.001	1.19	0.08	0.30	0.001	0.0049	Pb:0.05
G2	0.08	0.001	1.17	0.08	0.32	0.001	0.0052	Pb:0.12
G3	0.08	0.001	1.16	0.08	0.31	0.001	0.0054	Pb:0.18
G4	0.07	0.001	1.13	0.08	0.30	0.001	0.0053	Pb:0.26
G5	0.07	0.001	1.12	0.08	0.32	0.001	0.0050	Pb:0.35
G6	0.07	0.001	1.10	0.08	0.31	0.001	0.0129	Pb:0.26
G7	0.07	0.001	1.11	0.08	0.33	0.001	0.0054	Pb:0.25
H1	0.07	0.001	1.22	0.08	0.31	0.001	0.0051	Bi:0.005
H2	0.08	0.001	1.21	0.08	0.31	0.001	0.0052	Bi:0.04
H3	0.07	0.001	1.19	0.08	0.32	0.001	0.0049	Bi:0.11
H4	0.07	0.001	1.23	0.08	0.31	0.001	0.0051	Bi:0.17
H5	0.08	0.001	1.22	0.08	0.33	0.001	0.0159	Bi:0.06
H6	0.07	0.001	1.24	0.08	0.32	0.001	0.0047	Bi:0.07
J1	0.08	0.001	1.12	0.08	0.33	0.001	0.0048	Pb:0.18,Bi:0.03,Sn:0.01
J2	0.07	0.001	1.13	0.08	0.31	0.001	0.0177	Pb:0.17,Bi:0.03,Sn:0.02
J3	0.07	0.001	1.13	0.08	0.30	0.001	0.0049	Pb:0.18,Bi:0.04,Sn:0.01
J4	0.07	0.001	1.12	0.08	0.28	0.001	0.0052	In:0.25
J5	0.07	0.001	1.15	0.08	0.29	0.001	0.0047	In:0.12
J6	0.08	0.001	1.13	0.08	0.27	0.001	0.0049	In:0.02
J7	0.08	0.001	1.13	0.08	0.27	0.001	0.0182	In:0.05
J8	0.07	0.001	1.12	0.08	0.26	0.001	0.0047	In:0.04
J9	0.08	0.001	1.11	0.08	0.29	0.001	0.0048	Te:0.10,Se:0.15
J10	0.08	0.001	1.12	0.08	0.28	0.001	0.0051	Te:0.12,Se:0.13
J11	0.08	0.001	1.13	0.08	0.08	0.001	0.0050	Te:0.02,Se:0.04
J12	0.08	0.001	1.14	0.08	0.28	0.001	0.0189	Te:0.03,Se:0.02
J13	0.08	0.001	1.13	0.08	0.29	0.001	0.0052	Te:0.03,Se:0.02
J14	0.07	0.001	1.12	0.08	0.28	0.001	0.0042	Sn:0.35
J15	0.08	0.001	1.14	0.08	0.27	0.001	0.0048	Sn:0.21
J16	0.07	0.001	1.13	0.08	0.28	0.001	0.0050	Sn:0.10
J17	0.07	0.001	1.14	0.08	0.29	0.001	0.0044	Sn:0.02
J18	0.08	0.001	1.13	0.08	0.33	0.001	0.0045	Pb:0.18,Bi:0.03
K1	0.08	0.001	1.25	0.08	0.32	0.001	0.0054	Bi:0.03,Cr:0.2
K2	0.07	0.001	1.24	0.08	0.31	0.001	0.0056	Bi:0.12,Ni:0.1
K3	0.07	0.001	1.25	0.08	0.32	0.001	0.0073	Bi:0.07,Ti:0.02
K4	0.07	0.001	1.23	0.08	0.32	0.001	0.0082	Bi:0.09,Nb:0.02
K5	0.08	0.001	1.22	0.08	0.31	0.001	0.0049	Bi:0.01,V:0.04

[0043] It investigated [test specimen / which was obtained] about a ferritic grain size number and the Masanao nature. At this time, a ferritic grain size number is JIS about the grain size of the field which went into arbitration the cross section of the sample sampled ten places in 1/4 depth of a diameter in the surface section to the direction of a core from each rolled stock. G It measures based on 0552 and that average is calculated.

[0044] The amount of dissolution [N] is measured as follows. First, amount of N in steel ** is measured by the chemical analysis. Next, it asks for amount of N ** which analyzed the amount of AlN and has been combined with aluminum by the extract residue method. Those differences (**-**) serve as the amount of dissolution [N]. Here, when the relation between the amount of dissolution [N] and N content in steel was investigated in the experiment, although linear correspondence relation among

them was as shown in drawing 5 , I understand. Therefore, it turns out as conditions for not making deflection of a cold finished steel bar remain that you may specify with N content in steel instead of the amount of dissolution [N]. In addition, if in charge of analyzing the amount of AlN(s) by the describing [above] residue method, steel materials were first melted using 10% of acetylacetone system electrolytic solution, absorption filtration of the obtained solution was carried out with the mesh-size 0.2micrometer filter, and residue was extracted. The quantum of the AlN was carried out by neutralization analysis using this residue.

[0045] Next, although the rate of straightness success mentioned above estimated the Masanao nature, this rate of straightness success was computed in the following procedure. The cold finished steel bar of 8.0mmphi was first produced from the test specimen of 9.5mmphi. The correction at this time continued at the wire drawing, and was performed using 2 roll straighteners. Next, the deflection of a cold finished steel bar was measured with the laser for displacement measurement arranged on the center section by placing a cold finished steel bar on a span 400mm V block, and rotating it after cutting to 500mm die length.

[0046] If the cold finished steel bar has bent at this time, since a variation rate will arise in said center section along with rotation of a cold finished steel bar, the detection value of the laser for displacement measurement does not become fixed. Then, the value which deducted the minimum value from the maximum of the detection value while carrying out number rotation of the cold finished steel bar was calculated as an amount of displacement of a cold finished steel bar, and it turned at the amount of displacement here, and was defined as the amount. It performed 100 measurement numbers at a time to arbitration from each cold finished steel bar, and asked for them at the rate and percent by considering a thing with an amount [of deflection] of 50 micrometers or less as success. Moreover, obtained evaluation of the surface state of rolled stock and cold-finished-steel-bar machinability was performed as follows. These results are collectively shown in the following tables 3 and 4.

[0047] (Surface state of rolled stock) if there is no surface crack etc. — O — when it was, it was estimated as x.

(Cold-finished-steel-bar machinability) After carrying out cutting on the following cutting trial (cutting process by turning) conditions, machined surface granularity estimated the quality (O, x).

** Implement :P. 10 cutting speed: 150 m/min ** ** : It cuts deeply 0.05 mm/rev and is :2.0mm[0048].

[Table 3]

略号	熱間圧延仕上げ終了温度(℃)	冷却速度(℃／秒)	フェライト結晶粒度(番)	真直度合格率(%)	圧延材の表面状態	被削性	備考
A1	853	2.8	10.2	97	○	○	実施例
A2	848	2.6	10.1	97	○	○	実施例
A3	847	2.7	10.2	95	○	○	実施例
A4	854	2.9	10.1	92	○	○	実施例
A5	850	2.7	10.1	74	○	○	比較例
A6	851	2.7	10.1	63	○	○	比較例
A7	848	2.6	10.1	53	○	○	比較例
B1	718	2.0	12.4	53	○	○	比較例
B2	775	2.6	11.5	73	○	○	比較例
B3	851	1.4	9.4	99	○	○	実施例
B4	861	1.6	9.2	100	○	○	実施例
B5	803	0.5	8.3	99	○	○	実施例
B6	923	1.8	7.6	98	○	○	実施例
B7	827	1.5	10.3	97	○	○	実施例
B8	804	1.7	10.7	94	○	○	実施例
B9	738	2.2	12.1	57	○	○	比較例
B10	709	1.5	12.3	55	○	○	比較例
B11	802	3.8	11.7	65	○	○	比較例
B12	862	1.9	9.7	100	○	○	実施例
B13	883	1.8	8.9	99	○	○	実施例
B14	907	2.9	8.6	100	○	○	実施例
B15	938	2.9	7.9	99	○	○	実施例
B16	743	1.2	11.2	79	○	○	比較例
B17	809	4.0	11.9	63	○	○	比較例
B18	855	1.0	8.2	99	○	○	実施例
B19	801	3.1	11.2	77	○	○	比較例
B20	805	3.5	11.3	81	○	○	比較例
B21	815	3.0	10.9	91	○	○	実施例
C1	855	2.6	10.0	96	○	○	実施例
C2	843	2.2	10.1	97	○	○	実施例
C3	849	2.3	10.1	94	○	○	実施例
C4	820	1.2	10.0	91	○	○	実施例
D1	805	1.1	9.9	99	○	○	実施例
D2	863	2.4	9.8	99	○	○	実施例
D3	825	1.4	10.1	96	○	○	実施例
D4	830	1.6	10.1	94	○	○	実施例
D5	815	1.3	10.2	93	○	○	実施例

[0049]

[Table 4]

略号	熱間圧延仕上げ終了温度(℃)	冷却速度(℃／秒)	フェライト結晶粒度(番)	真直度合格率(%)	圧延材の表面状態	被削性	備考
E1	823	1. 4	10. 1	98	○	○	実施例
E2	818	1. 3	10. 2	95	○	○	実施例
E3	821	1. 2	10. 0	92	○	×	実施例
F1	833	1. 6	10. 1	96	○	○	実施例
F2	838	2. 0	10. 0	96	○	○	実施例
F3	832	2. 2	10. 2	93	○	×	実施例
G1	866	1. 5	9. 2	100	○	○	実施例
G2	867	1. 7	9. 3	100	○	○	実施例
G3	866	1. 8	9. 4	100	○	○	実施例
G4	874	1. 9	9. 3	98	○	○	実施例
G5	847	1. 2	9. 4	97	○	○	実施例
G6	850	1. 4	9. 5	70	○	○	比較例
G7	738	2. 8	12. 3	56	○	○	比較例
H1	864	1. 4	9. 2	100	○	○	実施例
H2	870	1. 6	9. 1	100	○	○	実施例
H3	851	1. 5	9. 5	99	○	○	実施例
H4	855	1. 5	9. 4	100	○	○	実施例
H5	858	1. 7	9. 4	59	○	○	比較例
H6	720	2. 4	12. 4	51	○	○	比較例
J1	854	1. 0	8. 5	99	○	○	実施例
J2	876	1. 2	8. 4	55	○	○	比較例
J3	728	2. 5	12. 4	52	○	○	比較例
J4	847	2. 2	10. 0	98	○	○	実施例
J5	844	2. 6	10. 2	97	○	○	実施例
J6	839	1. 5	9. 7	99	○	○	実施例
J7	830	1. 3	9. 7	52	○	○	比較例
J8	742	2. 6	12. 3	50	○	○	比較例
J9	849	1. 5	9. 5	100	○	○	実施例
J10	847	2. 2	10. 1	97	○	○	実施例
J11	855	1. 9	9. 8	99	○	○	実施例
J12	863	2. 2	9. 7	58	○	○	比較例
J13	717	1. 5	12. 4	54	○	○	比較例
J14	830	0. 9	8. 6	100	○	○	実施例
J15	839	1. 8	10. 0	93	○	○	実施例
J16	821	1. 4	10. 3	96	○	○	実施例
J17	854	1. 9	9. 7	99	○	○	実施例
J18	866	1. 7	9. 4	100	○	○	実施例
K1	838	2. 1	10. 2	97	○	○	実施例
K2	822	1. 8	10. 4	96	○	○	実施例
K3	855	1. 4	9. 4	100	○	○	実施例
K4	853	1. 6	9. 5	100	○	○	実施例
K5	854	1. 6	9. 5	100	○	○	実施例

[0050] From these results, it can consider as follows. A1–A6 show the result of having changed N content. Among these, since A1 – A4 satisfy the range which N content specifies by this invention, 92% or more is obtained at the rate of straightness success. On the other hand, in A5 (N:0.0125%) in which N content exceeds the range specified by this invention, the rate of truth direct success is [the amount of deflection by work hardening] large 74%, and, similarly the rate of truth direct success has not become 63% about A6 (N:0.0151%).

[0051] B1–B21 show the result of having changed the ferrite grain size. Among these, in B1 far exceeding the ferritic grain size number specified by this invention, the rate of straightness success was obtained only 53%. This is considered because the diameter of crystal grain became small too much and work hardening became large. Moreover, since B–2, B9–B11, and B16, B17, B19 and B20 had exceeded the ferritic grain size number specified by this invention, the rate of straightness success had become less than 90%.

[0052] On the other hand, the ferritic grain size number had become less than No. 11.0, the rate of straightness success was 90% or more, and especially, in B3 - B5, B12-B15, and B18, since the ferritic grain size number was less than No. 9.8, the rate of straightness success had reached to about about 100% B3-B8, B12-B15, and B18 and B21.

[0053] C1-C4 show the result of having changed Si content. In order that Si might cause solid solution strengthening of a ferrite, since it was a disadvantageous MnS gestalt for machinability, machined surface granularity became coarse and machinability fell in C3 and C4 by which Si content exceeds 0.05% which is the desirable upper limit of this invention. moreover, since dissolution work hardening into a ferrite was caused, the value also with the rate of straightness success low a little was shown (94% of each, 91%).

[0054] D1-D5 show the result of having changed Mn content. Among these, since D2, D3, and D4 had Mn content within the limits of [desirable] this invention, the rate of straightness success attained 90% or more, but in D5 exceeding the upper limit specified by this invention, since MnS deposited mostly, many cracks occurred on the rolled stock front face. Moreover, although the rate of straightness success obtained 99%, the surface crack by a lot of liquid phase FeS at the time of rolling generated D1 in which Mn content is less than the desirable lower limit of this invention.

[0055] E1-E3 show the result of having changed P content. In the thing of E3 exceeding the desirable upper limit of this invention, machined surface granularity also deteriorated by steel-materials degree-of-hardness rise **** tool life fall. Moreover, since dissolution work hardening into a ferrite was caused, 92% of straightness success and a value low a little were shown.

[0056] F1-F3 show the result of having changed aluminum content. In F3 by which aluminum content exceeds the desirable upper limit of this invention, since MnS presented the disadvantageous gestalt for machinability by oxygen density fall, machined surface granularity became coarse. Moreover, work hardening was lengthened by deposit of a lot of AlN grains, and, for the ****** reason, the rate of straightness success also indicated the value low a little to be 93%.

[0057] Although G1-G7 investigated the effect by Pb addition, as for the thing of G1-G5 whose Pb content is 0.4% or less of the desirable upper limit of this invention, the rate of straightness success was able to obtain 97% or more. However, in G6 (N:0.0129%) by which N content exceeds 0.01% specified by this invention, the rate of truth direct success was obtained only 70%. Moreover, in G7 (grain-size-number number: No. 12.3) by which a ferritic grain size number exceeds No. 11 specified by

this invention, the rate of straightness success was obtained only 56%.

[0058] H1–H6 show the result of having changed Bi content. In H1–H4 whose Bi content is 0.4% or less of the desirable upper limit of this invention, the rate of straightness success was able to obtain 99% or more. However, in H5 (N:0.0159%) by which N content exceeds 0.01% specified by this invention, the rate of straightness success was 59%. Moreover, in H6 (grain size number: No. 12.4) by which a ferritic grain size number exceeds No. 11 specified by this invention, the rate of straightness success was obtained only 51%.

[0059] J1–J18 show the result of having made various free-cutting elements (Pb, Bi, Te, Se, Sn, In) containing. Among these, although 90% or more of rates of straightness success was securable in J1, J4, J5, J6, J9, J10, J11, J14–J18 which made these elements contain within limits specified by this invention In J2 (N:0.0177%), J7 (N:0.0182%), and J12 by which N content exceeds 0.01% specified by this invention (N:0.0189%), the rates of straightness success were 55%, 52%, and 58% by the increment in the rate of work hardening by N dissolution, respectively. Moreover, the rate of truth direct success stopped at 52%, 50% and 54%, and a low value J3 (grain-size-number number: No. 12.4), J8 (grain-size-number number: No. 12.3), and J13 by which a ferritic grain size number exceeds No. 11 specified by this invention (grain-size-number number: No. 12.4), respectively.

[0060] Although K1 – K5 showed the result of having made elements, such as Cr, nickel, Ti, Nb, and V, containing, the rate of straightness success showed 96% or more of high value for all.

[0061]

[Effect of the Invention] This invention is constituted as mentioned above and the steel materials which can improve the Masanao nature (Masanao nature after cold drawing processing) of a roller shank required in order to attain a high paper feed precision which poses a problem with feeding and a delivery roller have been realized.

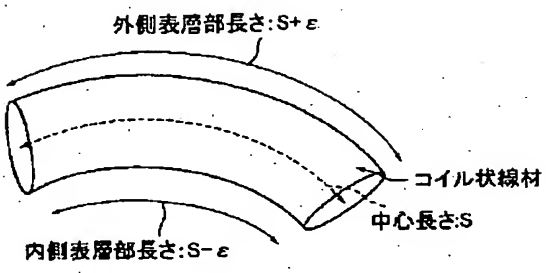
[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is drawing for explaining the difference of the die length of the inside surface section of coiled form rolled stock, and the outside surface section.
[Drawing 2] It is the approximate account Fig. having shown the amount of distortion which remains in drawing and the corrected cold finished steel bar.
[Drawing 3] It is the graph which showed the relation between a ferritic grain size number and the rate of straightness success.
[Drawing 4] It is the graph which showed the relation between the content in [N] steel, and the rate of straightness success.
[Drawing 5] It is the graph which showed the relation between the amount of N in steel, and the amount of dissolution [N].

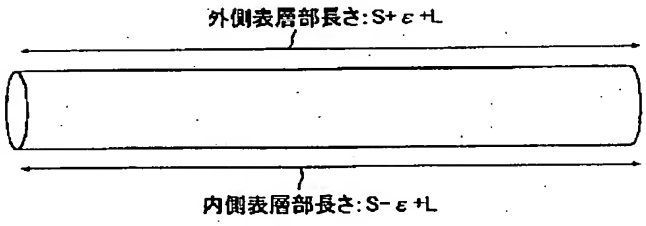
[Translation done.]

Drawing selection drawing 1



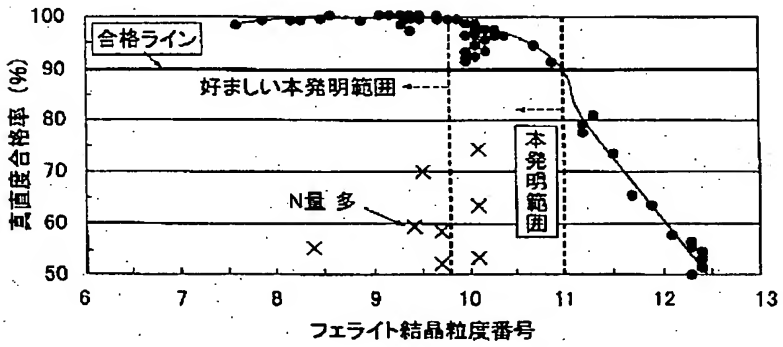
[Translation done.]

Drawing selection drawing 2



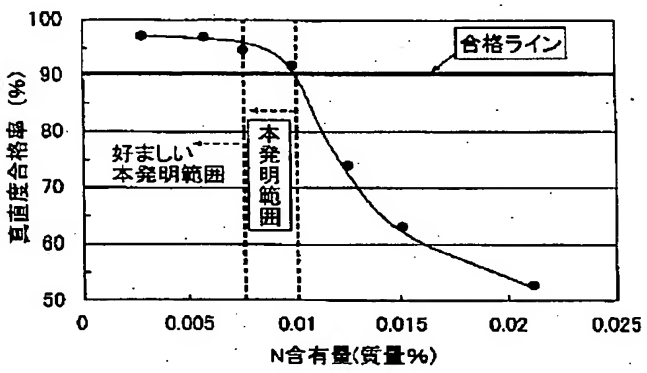
[Translation done.]

Drawing selection drawing 3



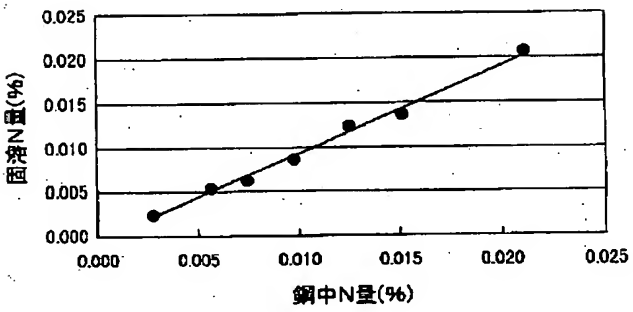
[Translation done.]

Drawing selection drawing 4



[Translation done.]

Drawing selection drawing 5



[Translation done.]